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ABSTRACT

A study was devised for investigating developmental change in the extent to which children use a speech recoding process during silent reading to obtain meaning from sentences. The subjects, 48 second and 48 sixth grade students, were shown a series of single sentences that included equal numbers of sentences at the second, fourth, and sixth grade levels. Each sentence was followed by a test sentence either identical or semantically changed from the original. The child's task was to detect the test sentence change. Subjects performed the task twice, once while reading silently and once while vocalizing a word (to suppress speech recoding). Analyses of the data measured latency to decision, accuracy of detection of sentence changes (signal detection), and detection of semantic change in test sentences. The data showed that children who were just beginning to read did rely more on a speech recode process during reading than did the older children with more fluent reading skills. Further, children used the recode process to facilitate sentence comprehension, particularly when trying to understand more difficult sentences. Contrary to prediction, latency to decision was greater for silent reading than for reading while vocalizing. (Author/RL)

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Children's Use of Speech Recoding to Obtain Meaning from Sentences

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This study investigated developmental change in the extent to which children rely on speech recoding during reading to obtain meaning from sentences. Reading researchers offer two views of how readers derive meaning from printed text. One view maintains that meaning from printed text is extracted directly by forming an association between the printed word as a visual array of letters and the meaning represented by the array. A second view maintains that readers get from print to meaning indirectly via an intermediary speech recode process. Readers first recode the printed word into a speech code which is then used to access meaning in a manner similar to the way one gets meaning when listening to speech.

No one doubts that strictly visual print-to-meaning reading does occur, especially by adult fluent readers. Similarly, no one doubts that on occasion the indirect speech recode path is used even by adults. The primary controversary surrounds the question of whether the indirect path is the predominant path used by beginning readers. This study addressed this question.

Rationale

In Fluent Readers: Speech Recoding

Functions in Working Memory

Several models of fluent reading address the presence or absence of a speech recoding process during reading, the stage during which speech recoding occurs, and the function of recoding. Kleiman (1975) proposed that recoding occurs in working memory as the means by which single items are kept active long enough to be comprehended. In order to test the role of speech recoding during working memory in adult fluent readers, Kleiman (1975) and Levy (1975, 1977) devised tasks which closely approximate

reading for the purpose of learning. These investigators used sentences as stimuli and procedures which prevent speech recoding during reading (counting out loud or saying the word "double" repeatedly). They then compared the effect on memory of this suppression to performance of a control group.

Both Kleiman and Levy's data supported the working memory hypothesis. Tasks which suppressed speech recoding during reading had a deleterious effect on sentence memory. Lexical access (i.e., word recognition) was unaffected by the suppression task. Similarly, in a comparable listening task sentence memory was unaffected by the suppression task. These results lend credence to a speech recode process unique to reading which functions in working memory (as opposed to a general interference explanation).

In Beginning Readers: Does Speech Recoding Have a Similar Function?

Two studies (Barron & Baron, 1977; Rader, 1976) have specifically investigated a developmental change in the extent to which children rely on speech recoding during reading of individual words. Neither study used sentences as stimuli. In both studies children made either rhyme or semantic decisions after having viewed pairs of words or word-picture pairs. The same stimuli were used across all grades; for Rader, grades 2, 3, 6, and graduate students, and for Barron and Baron, grades 1, 2, 4, 6, and 8. Neither study found a developmental change in the paths used to obtain meaning from printed words. Even children in grade 1 were able to go directly to meaning of printed words without first recoding to speech.

However, the results from these two studies apply only to the process by which children across grades get meaning from single words. In view of the finding that fluent adult readers need and use speech recoding for sentence comprehension, it stands to reason that children also rely on a speech recode process when faced with the memory demands of sentences.

Method

Design, Procedure, Stimuli, and Subjects

In this study, 48 second and 48 sixth graders were shown two series of slides, each containing one sentence. Each stimulus sentence was followed by 30 seconds of interference tasks and then a test sentence which was either a semantically changed version or the original sentence. The child's task was to detect the test sentence change, respond "same" or "different," and when "different," describe the change in sentence meaning that occurred from stimulus to test sentence. These answers were later scored on a scale of 0 (no awareness of meaning change in test sentence or an incorrect response to an identical sentence) to 4 (complete explanation of meaning change in test sentence). These meaning scores served both to confirm that a change was actually detected and not guessed, and to indicate the extent to which the child detected a semantic as opposed to graphemic change.

Children read one set of 24 sentences silently and a second set of 24 while vocalizing the word "double" repeatedly. Equal numbers of sentences at three grade levels (2, 4, and 6) were included. We hypothesized (a) that children's use of speech-recoding during reading of sentences would be demonstrated by a suppression effect as measured by longer latency to decision and proportionately fewer correct detections of

sentence change (i.e., signal detection) during the vocalization condition; (b) that children's use of speech recoding during reading declines from grade 2 to 6; and (c) that speech recoding is used more when reading difficult, as opposed to easy, material. We investigated these hypotheses and the differential use of speech recoding by boys and girls by manipulating reading condition (2, 4, 6), and type of test sentence (changed, unchanged), and classifying on grade (2 and 6) and sex.

Results and Discussion

The data analysis was carried out in three phases. First, a 2 (grade) by 2 (sex) multivariate analysis of variance was done with latency to decision and signal detection as the two dependent variables. Second, a post hoc analysis was done on meaning scores. Last, four dependent *t* tests were done on first versus second half of sentences for second and sixth graders under silent and suppressed reading conditions to test for either a practice or fatigue effect.

The results of this study confirmed our hypothesis that children who are just beginning to read rely more heavily on a speech recode process during reading than do older children with more fluent reading skills. Further, it would seem that as with adults, children use the recode process for sentence comprehension, particularly when trying to understand more difficult sentences. Several findings support these conclusions (unless otherwise indicated, significance refers both to findings from the multivariate analysis of signal detection and latency to decision, and the post hoc analysis of meaning scores):

1. The main effects for reading condition, grade, and sentence level reached significance indicating that there was a suppression effect,

the performance of sixth graders was superior to that of second graders, and performance declined with increasing sentence level.

2. The significant grade by sentence level interaction confirmed that sentences did, indeed, approximate the difficulty levels of grade 2, 4, and 6 sentences. Second graders found the task more difficult with each new sentence level; sixth graders had no difficulty until Sentence Level 4, somewhat earlier than we would have expected.

3. Our principle hypothesis that older more fluent readers make less use of a speech recode process than do younger beginning readers was confirmed by the significant interaction of grade by reading condition. Several points are important. First, although more evident in second grade, the suppression effect is still very real in sixth grade. This indicates that a recode process had been functioning and when suppressed, resulted in deficient performance on the detection task.

Second, the significance of this grade by reading condition interaction on meaning scores strongly suggests that the suppression of speech recoding had a deleterious effect on semantic sentence memory. Without the meaning score data, we would not have known whether the data from signal detection and latency indicated detection of semantic change or simply detection of change in the visual (graphemic) representation.

Third, speech recoding is time consuming (Barron, 1978; Kleiman, 1975; Meyer, Schvaneveldt, & Ruddy, 1974). Therefore, it seemed reasonable to expect that one manifestation of the suppression effect would be longer latencies to decision after reading while vocalizing. This did not materialize. On the contrary, latencies to decision were significantly longer after silent reading. One explanation for this apparent reversal

is that a practice effect was operating. Since silent reading always preceded reading while vocalizing, children may have become more adept at the procedure and made quicker decisions during the second slide set. If a practice effect was operating, however, there should have been a comparable practice effect within each reading condition. This was not the case. For both second and sixth graders analyzed separately, errors made during the first 12 test sentences were essentially comparable to errors made during the last 12 test sentences of each slide set.

A more plausible explanation for longer latencies to decision is that during silent reading, speech recoding functioned in working memory to form and/or store a complete representation of all components of the stimulus sentence in long-term memory. Thus when the test sentence was read another sentence representation had to be formed, again through recoding. The child then had to compare the two representations prior to making a same/different decision.

By contrast, since speech recoding was suppressed while simultaneously reading the stimulus sentence and vocalizing "double," it is possible that an incorrect representation or only a partial representation of the stimulus sentence was formed. If the essential propositions of the stimulus sentence were inadequately processed in working memory, the representation transferred to long-term memory would be deficient. Therefore, while reading the test sentence, when children attempted to compare the test sentence with the representation of the stimulus sentence in memory, the comparison process broke down as soon as they reached a unit within the test sentence which had no comparable representation in long-term memory.

4. The significant interaction of reading condition by sentence level confirms that speech recoding is used more when reading difficult material. The suppression effect was greater at each new level of sentence difficulty.

5. From the meaning score analysis, we have additional findings. The meaning scores of second-grade girls were significantly higher than those of the boys; however, in sixth grade, the boys outperformed the girls. Second-grade boys were significantly more affected by the read-while-vocalizing task than were the scores of second-grade girls; in sixth grade, the meaning scores of boys and girls were equally affected by the vocalization task. Interestingly, Mason (1977) found a similar grade by sex interaction on a meaning-related association task with second and fifth graders.

If we can assume that our meaning scores measure comprehension of sentence meaning, these findings suggest that among beginning readers, girls understand the sentences they read better than boys, but among older more fluent readers, the reverse is true. In addition, sentence comprehension of younger less fluent readers, particularly boys, is more adversely affected by the suppression of speech recoding than that of older more skilled readers. Last, the sentence comprehension of sixth graders is still somewhat affected by suppression of speech recoding, though to a lesser extent than that of second graders and affecting both boys and girls about equally.

Summary

In conclusion, our findings indicate that children use speech recoding in sentence comprehension. When reading difficult sentences, the memory demands may be such that speech recoding is necessary to keep sentence parts active in working memory until the sentence is understood.

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Table 3

Means and Standard Deviations of Latencies to Decision (in Seconds) by Second and Sixth Graders for Changed and Unchanged Test Sentences at Three Sentence Levels and Two Reading Conditions

Reading Condition and Test Sentence Type	Grade 2 Mean	Grade 2 SD	Grade 6 Mean	Grade 6 SD
Sentence Level 2				
Silent				
Changed	2.90	.76	2.06	.47
Unchanged	2.60	.76	1.78	.55
Suppressed				
Changed	2.73	.69	1.82	.50
Unchanged	2.51	.75	1.66	.49
Sentence Level 4				
Silent				
Changed	3.20	.85	2.20	.55
Unchanged	3.23	.94	2.27	.58
Suppressed				
Changed	3.08	.71	2.09	.64
Unchanged	3.12	.81	2.18	.58
Sentence Level 6				
Silent				
Changed	3.77	.82	2.53	.71
Unchanged	3.56	1.00	2.42	.71
Suppressed				
Changed	3.35	1.00	2.39	.74
Unchanged	3.44	1.02	2.28	.74

Table 2

Means and Standard Deviations of d', a Measure of Signal Detection, by Second and Sixth Graders at Three Sentence Levels and Two Reading Conditions

Grade and Reading Condition	d' Mean	d' SD
Sentence Level 2		
Grade 2		
Silent	3.56	1.33
Suppressed	2.49	1.63
Grade 6		
Silent	4.08	.94
Suppressed	3.61	1.14
Sentence Level 4		
Grade 2		
Silent	3.12	1.30
Suppressed	1.47	1.51
Grade 6		
Silent	3.98	1.04
Suppressed	2.59	1.21
Sentence Level 6		
Grade 2		
Silent	2.57	1.59
Suppressed	1.36	1.26
Grade 6		
Silent	3.76	1.14
Suppressed	2.52	1.39

Note. Possible range of values for d' = 4.64 to -4.64.

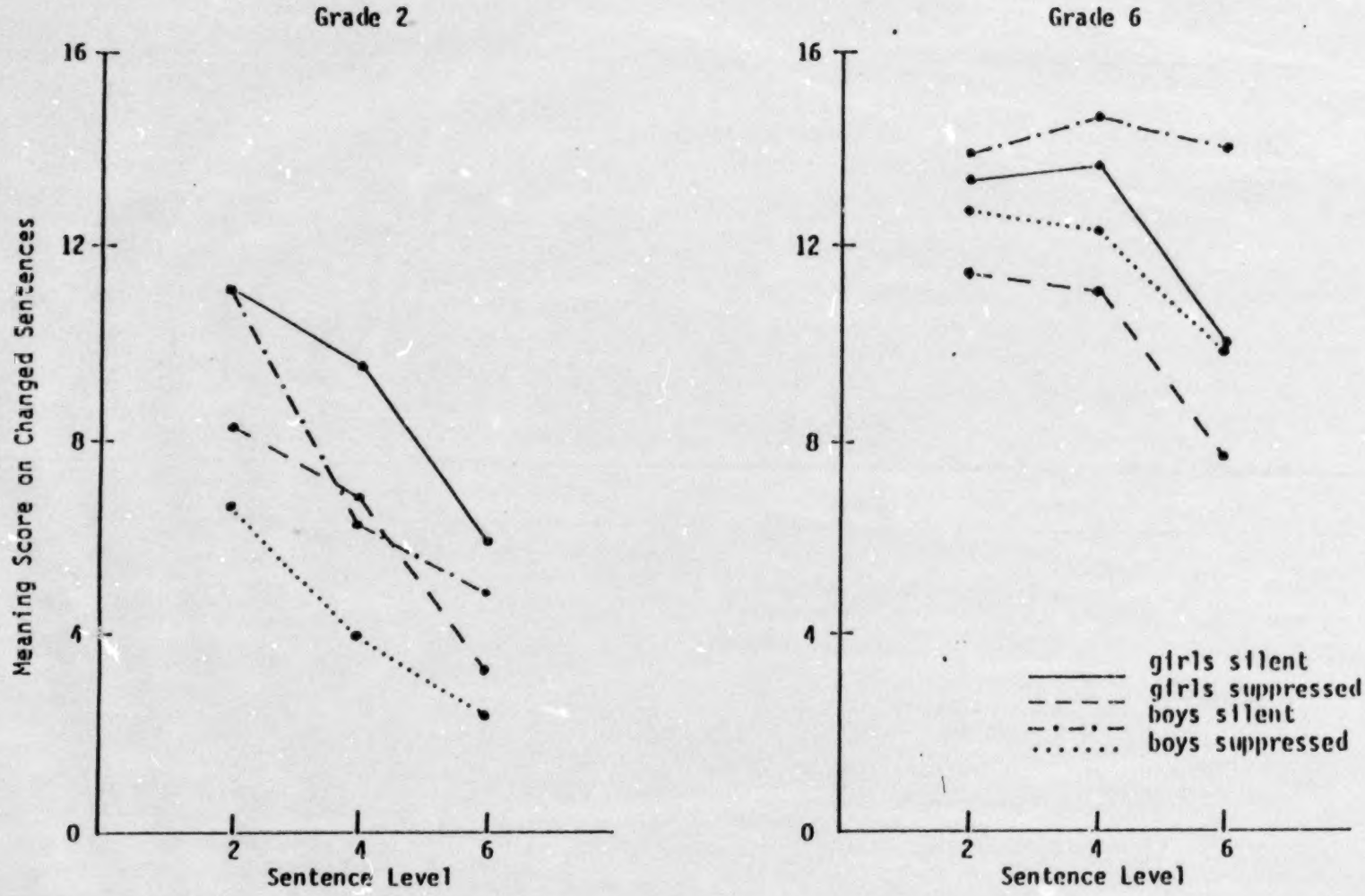

Figure 1. Meaning scores for children in grades 2 and 6 on three levels of changed sentences for silent and suppressed reading conditions.